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Single-Molecule Toroics in Ising-type lanthanide molecular clusters

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The toroidal magnetic moment [1] is an antisymmetric combination of second-order magnetic moments, possessing distinct symmetry from first-order electromagnetic moments due to the sign change under both space and time inversion. It has been observed for the first time in $LiCoPO_4$ as a homogeneous distribution of toroidal polarization [2], which was also the first evidence for the fourth fundamental form of ferroic order, the ferrotoroidicity [3]. Recently an almost net toroidal moment has been detected in Dy_3 triangles, implying the existence of toroidal quantum states in these complexes [4]. Single-molecule toroics (SMTs) are defined, by analogy with single-molecule magnets (SMMs), as bistable molecules with toroidal magnetic state, which seem to be most promising for future applications in quantum computing and information storage and as molecular multiferroic materials with magnetoelectric effect. The key features offering advantages to CMTs as potential units for storage and processing of information are (i) their insensitivity to external homogeneous magnetic fields and a remarkably weak magnetic interaction between themselves and (ii) the possibility to manipulate the toroidal states by electrical means (charge currents and variable electric fields). In this interdisciplinary research area that spans chemistry, physics and material sciences, synthetic chemists have already produced SMT systems suitable for detailed experimental study, while ab initio calculations have proven their reliability in the description of toroidal magnetization [6] In this presentation, I will review the emerging field of SMTs with particular focus on how recent studies tend to address the issue of toroidal arrangement of local magnetic moment on the metal sites. Nine lanthanide-based SMTs will be presented showing, in particular, that the assembly of wheel-shaped complexes with the high symmetry of the molecule unit and combining strong intermetallic dipolar interactions with strong axial anisotropy on the metal sites represents the most promising route toward the design of efficient SMTs.

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